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VCE UNITS 1 & 2

applied computing

GARY BASS
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Unit 2

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Preface

This seventh edition of *Applied Computing VCE Units 1 & 2* incorporates the changes to the VCAA VCE Applied Computing Study Design that took effect from 2020.

This textbook looks at how individuals and organisations use, and can be affected by, information systems in their daily lives.

We believe that teachers and students require a text that focuses on the **Areas of Study** specified in the **Study Design**, and that presents information in a sequence that allows easy transition from theory into practical assessment tasks. We have therefore written this textbook so that a class can begin at Chapter 1 and work their way systematically through to the end. Students will encounter material relating to the **key knowledge** dot points for each **Outcome** before they reach the special section that describes the Outcome. The Study Design outlines key skills that indicate how the knowledge can be applied to produce a solution to an information problem. These Outcome preparation sections occur regularly throughout the textbook, and flag an appropriate point in the student's development for each Outcome to be completed. The authors have covered all key knowledge dot points for the Outcomes from the Applied Computing VCE Units 1 & 2 course.

Our approach has been to focus on the key knowledge required for each school-assessed Outcome, and to ensure that students are well prepared for these; however, there is considerable duplication in the Study Design relating to the knowledge required for many of the outcomes. We have found that, with an Outcomes approach, we are sometimes covering the same material several times. For example, knowledge of a problem-solving methodology is listed as key knowledge for many different outcomes. In these cases, we have tried to provide a general coverage in the first instance, and specifically apply the concept to a situation relevant to the related outcome on subsequent encounters.

The authors assume teachers will develop the required key skills with their students within the context of the key knowledge addressed in this textbook and the resources available to them.

We have incorporated a margin column in the text that provides additional information and reinforcement of key concepts. The margin column also includes activities related to the topics covered in the text, and consideration of issues relevant to the use of information systems.

Outcome features are included at several points in the book, indicating the nature of the tasks that students are to undertake in the completion of the school-assessed Outcome. The steps required to complete the Outcome are listed, together with advice and suggestions for approaching the task. The output and support material needed for submission are described. Sample tasks and further advice relating to the outcomes are available at https://www.nelsonnet.com.au.

The chapters are organised to present the optimum amount of information in the most effective manner. The text is presented in concise, clearly identified sections to guide students through the text. Each chapter is organised into the sections described on pages vii–viii.

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About the authors

Gary Bass teaches VCE Applied Computing at Year 11 and Year 12 in an online course environment at Virtual School Victoria. Previously he has taught VCE Physics, as well as developing and delivering middle school ICT courses. Gary has presented at DLTV DigiCON and the annual IT teachers conference on many topics, including 'Pop-up Makerspace', 'Big Data requires huge analysis – data visualisation', 'AR + VR = Mixed reality', and 'Marshall McLuhan – Medium is the message'.

Selina Dennis is a Software Development and English Language teacher for the Department of Education and has been heavily involved in past and present Computing Study Designs. Selina has a Bachelor of Arts and Science in Computer Science and Linguistics from the University of Melbourne, and has a particular interest in Computational Linguistics. She spent several years in California in the computing industry as an Engineering Manager and Director of Engineering before entering teaching.

Associate Professor Therese Keane, Deputy Chair of the Department of Education at Swinburne University, has worked in a variety of school settings, where she has taught IT and led in K–12 education as the Director of ICT. Her passion and many achievements in the ICT in Education and Robotics space have been acknowledged by her peers in the numerous national and state awards she has received. Therese has presented numerous seminars and workshops for teachers involved in the teaching of IT. She has written several textbooks in all units of Senior IT in Victoria, and in VCE Information Technology since 1995. Therese's research interests include the use of technology in education, gender inequalities in STEM-based subjects, robotics in education and computers in schools for teaching and learning purposes. Therese is involved with the FIRST LEGO League as the Championship Tournament Director for Victoria, and is a lead mentor for the RoboCats – an all-girl robotics team that participates in the FIRST Robotics Competition.

Anthony Sullivan is a Curriculum and Learning Specialist at Monash College, where he is responsible for creating assessment and learning materials for accounting and computing subjects as part of the Monash University Foundation Year program. Before this, Anthony had been teaching business and computing subjects for more than 25 years. He has taught in both government and non-government settings in Australia and taught computing and information technology courses in schools in Asia and the United Kingdom. Anthony has also been a VCE Examination Assessor, a member of the committee that reviewed and wrote the previous study design for VCE Computing, and has written a range of commercial resources related to VCE Computing. He has presented at a number of conferences and professional development events and has also presented at student examination preparation sessions.

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How to use this book

KEY KNOWLEDGE

The key knowledge from the VCAA Applied Computing VCE Units 1 & 2 Study Design that you will cover in each chapter is listed on the first page of each chapter. The list includes key knowledge specified in the Outcome related to the chapter.

FOR THE STUDENT

The first page of each chapter includes an overview of the chapter's contents so that you are aware of the material you will encounter.

FOR THE TEACHER

This section is for your teacher and outlines how the chapter fits into the overall study of Applied Computing, and indicates how the material relates to the completion of Outcomes.

CHAPTERS

The major learning material that you will encounter in the chapter is presented as text, photographs, screenshots and illustrations. The text describes in detail the theory associated with the stated outcomes of the Applied Computing VCE Units 1 & 2 Study Design in easy-to-understand language. The photographs show hardware, software and other objects that have been described in the text. Illustrations are used to demonstrate concepts that are more easily explained in this manner.

Throughout the chapter, glossary terms are highlighted in bold, light-blue text and you can find their definitions at the end of the chapter, in **Essential terms**.

MARGIN COLUMN

The margin column contains further explanations that support the main text, weblink icons, additional material outside the Study Design and cross-references to material covered elsewhere in the textbook. Issues relevant to Applied Computing that you can discuss with your classmates are also included in the form of 'Think about Applied Computing' boxes (right).

3.1 THINK ABOUT APPLIED COMPUTING

Project management tools are useful to find the perfect number of people needed on a task so it is finished as quickly as possible without anyone being idle. Use software to develop a Gantt chart to plan the baking of a cake. Assume you can use as many cooks as you want.

CHAPTER SUMMARY

The chapter summary at the end of each chapter is divided into two main parts to help you review each chapter.

Essential terms lists the glossary terms that have been highlighted throughout the chapter.

Important facts is a list of summaries, ideas, processes and statements relevant to the chapter, in the order in which they occur in the chapter.

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TEST YOUR KNOWLEDGE

These are short-answer questions that are provided to help you when reviewing the chapter material. The questions are grouped, and identified with a section of the text, to allow your teacher to direct appropriate questions based on material covered in class. Teachers will be able to access answers to these questions at **https://www.nelsonnet.com.au**.

APPLY YOUR KNOWLEDGE

Each chapter concludes with a set of questions requiring you to demonstrate that you can apply the theory from the chapter to more complex questions. The style of questions reflects what you can expect in the end-of-year examination. Teachers will be able to access suggested responses to these applications at **https://www.nelsonnet.com.au**.

PREPARING FOR THE OUTCOMES

This section appears at points in the course where it is appropriate for you to complete an Outcome task. The information provided describes what you need to do in the Outcome, the suggested steps to be followed in the completion of the task and the material that needs to be submitted for assessment.

NELSONNET

The NelsonNet student website contains:

- multiple-choice quizzes for each chapter, mirroring the VCAA Unit 3 & 4 exam.
- additional material such as spreadsheets and infographics.

A weblink page is also provided for all weblinks that appear in the margins throughout the textbook. This is accessible at the student website at **https://nelsonnet.com.au.**

The NelsonNet teacher website is accessible only to teachers and it contains:

- answers for the **Test your knowledge** and **Apply your knowledge** questions in the book
- sample SACs
- chapter tests
- practice exams.

Please note that complimentary access to NelsonNet and the NelsonNetBook is only available to teachers who use the accompanying student textbook as a core educational resource in their classroom. Contact your sales representative for information about access codes and conditions.

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Outcomes

OUTCOME	KEY KNOWLEDGE	LOCATION
Unit 1 Area of Study 1 Outcome 1	**Data analysis** On completion of this unit the student should be able to interpret teacher-provided solution requirements and designs, collect and manipulate data, analyse patterns and relationships, and develop data visualisations to present findings.	
Data and information	• types and purposes of qualitative and quantitative data	p. 3
	• characteristics of data and information	p. 5
	• sources, methods and techniques for acquiring and referencing primary and secondary data and information	p. 5
	• interpretation of information for communication and decision making	p. 11
	• factors affecting the quality of data and information, such as accuracy, bias, integrity, relevance and reliability	p. 12
	• characteristics of data types and data structures relevant to selected software tools	p. 15
	• procedures for the legal and ethical collection and use of data and information, such as using consent forms	p. 18
	• techniques for protecting data and information from misuse, such as de-identifying personal data and the use of physical and software security controls	p. 23
Approaches to problem solving	• structural characteristics of spreadsheets and databases, such as cells, fields, records and tables	p. 72
	• types and purposes of data visualisations suitable for educating, entertaining, informing and persuading audiences	p. 39
	• functional and non-functional requirements of solutions, constraints and scope	p. 59
	• design tools for representing the functionality and appearance of databases, spreadsheets and data visualisations, such as annotated diagrams and mock-ups	p. 63
	• formats and conventions suitable for databases, spreadsheets and data visualisations	p. 68
	• software functions and techniques for efficiently and effectively manipulating, validating and testing data to develop databases, spreadsheets and data visualisations	p. 77
Interactions and impacts	• Australian Privacy Principles relating to the acquisition, management and communication of data and information including non-identification of individuals (Principle 2), information only being held for its primary purpose (Principle 6) and the security measures used to protect personal information (Principle 11)	p. 28
	• ethical issues arising from the acquisition, storage and use of data and information	p. 31
Key skills	• acquire and reference data and information from primary and secondary sources, taking into account legal and ethical considerations	
	• analyse the selected data, and discuss the relationships and patterns identified	
	• interpret solution requirements, constraints and scope	
	• interpret designs using appropriate design tools to represent the functionality and appearance of databases, spreadsheets and data visualisations	
	• use software, and select and apply functions, formats, conventions, data validation and testing techniques to efficiently manipulate data and create data visualisations	
	• compare and interpret data visualisations	

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OUTCOME	KEY KNOWLEDGE	LOCATION
Unit 1 Area of Study 2 Outcome 2	**Programming** On completion of this unit the student should be able to interpret teacher-provided solution requirements to design, develop and evaluate a software solution using a programming language.	
Digital systems	• functions and capabilities of key hardware and software components of digital systems required for processing, storing and communicating data and information	p. 110
Data and information	• characteristics of data types	p. 124
	• types of data structures	p. 126
Approaches to problem solving	• features of functional and non-functional solution requirements, constraints and scope	p. 120
	• design tools for representing the functionality and appearance of solution designs such as data dictionaries, mock-ups and pseudocode	p. 134
	• naming conventions for solution elements such as files, functions, methods and variables	p. 136
	• processing features of a programming language	p. 152
	• characteristics of internal documentation	p. 164
	• formatting and structural characteristics of input and output such as file formats	p. 166
	• testing and debugging techniques to ensure software solutions meet requirements such as test tables and test data	p. 169
	• techniques for evaluating the efficiency and effectiveness of software solutions	p. 177
	• project plans to coordinate and monitor the tasks, including sequencing and time allocation to create software solutions	p. 118
Key skills	• analyse solution requirements to develop a software solution	p. 120
	• select and use appropriate design tools to represent solution designs	p. 133
	• use a range of data types and data structures	pp. 124, 126
	• develop a software solution using appropriate processing features of a programming language	p. 152
	• design and apply suitable testing and debugging techniques using appropriate test data	p. 169
	• evaluate the efficiency and effectiveness of the software solution to meet requirements	p. 177
	• document and monitor project plans using software	p. 118

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OUTCOME	KEY KNOWLEDGE	LOCATION
Unit 2 Area of Study 1 Outcome 1	**Innovative solutions** On completion of this unit the student should be able to, in collaboration with other students, analyse, design, develop and evaluate an innovative solution to an identified need or opportunity involving a digital system.	
Digital systems	• components of digital systems	p. 195
	• types of digital devices used for a range of current and emerging applications such as smart phones, smart refrigerators and virtual assistants	p. 195
	• emerging trends in digital systems and the importance of innovation to organisations, such as improving efficiency and effectiveness of customer service and maintaining competitiveness	p. 195
	• functions and capabilities of digital systems used by individuals and organisations, such as assistive technologies, financial services, global positioning system (GPS) devices, robotics and traffic management	p. 208
Data and information	• techniques for collecting data to determine user needs and requirements, such as interviews and surveys	p. 246
Approaches to problem solving	• techniques for documenting the development of solutions	p. 242
	• solution specifications such as functional and non-functional requirements, constraints and scope	p. 247
	• characteristics of creative and innovative solutions	p. 251
	• design tools and techniques for representing solution designs, such as mock-ups, pseudocode, sitemaps and storyboards	p. 252
	• functions and techniques for developing innovative solutions	p. 267
	• techniques for validating and testing solutions	p. 261
	• evaluation criteria and techniques for evaluating the efficiency and effectiveness of innovative solutions	p. 272
	• tools and techniques for coordinating and monitoring projects, such as Gantt charts	p. 242
Interactions and impact	• goals and objectives of digital systems	p. 218
	• economic issues involving emerging technologies, such as access, deskilling, job loss, misuse and sustainability	p. 219
	• the impact of current and emerging technologies, such as automation, cyberbullying and the decline of physical human interactions and interpersonal skills	p. 224
	• key legislation and how emerging technologies are affected by: the *Copyright Act 1968*, the *Health Records Act 2001*, the *Privacy Act 1988* and the *Privacy and Protection Act 2014*	p. 234
	• ethical issues arising from the development of emerging technologies	p. 239

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OUTCOME	KEY KNOWLEDGE	LOCATION
Key skills	• investigate a problem, need or opportunity and identify potential users and purpose	p. 251
	• propose a range of methods to collect data for analysis	p. 246
	• analyse and document solution requirements to develop an innovative solution	p. 247
	• select and use appropriate design tools for generating solution designs	p. 257
	• develop an innovative solution using appropriate digital systems	p. 267
	• document the development of the innovative solution	p. 242
	• design and apply suitable validation and testing techniques	p. 262
	• identify and discuss potential legal and ethical issues affecting the development of an innovative solution	p. 239
	• apply evaluation criteria and evaluate the efficiency and effectiveness of an innovative solution to meet a need or opportunity	p. 272
	• document, monitor and modify project plans using a Gantt chart	p. 242
Unit 2 Area of Study 2 Outcome 2	**Network security** On completion of this unit the student should be able to respond to a teacher-provided case study to examine the capabilities and vulnerabilities of a network, design a network solution, discuss the threats to data and information, and propose strategies to protect the security of data and information.	
Digital systems	• applications and capabilities of LANs, Wide Area Networks (WANs) and Wireless Personal Area Networks (WPANs)	p. 284
	• functions and characteristics of key hardware and software components of networks required for communicating and storing data and information	p. 290
	• strengths and limitations of wired, wireless and mobile communications technology, measured in terms of cost, data storage options, data transfer rate, reliability and security	p. 297
	• technical underpinnings of intranets, the internet and virtual private networks	p. 305
	• design tools for representing the appearance of networks	p. 308
	• security threats to data and information, such as improper credential management, malicious software, outdated versions of software and weak passwords	p. 309
	• technical underpinnings of malware that can intentionally threaten the security of networks, such as denial of service attacks on websites, spyware, viruses and worms	p. 310
	• data and network protection strategies, such as authentication techniques and symmetric and asymmetric encryption methods	p. 313
	• preventative practices to reduce risks to networks, such as application of firmware, disaster recovery plans, operating system updates, software malware updates and staff procedures	p. 317
	• technical underpinnings of intrusion detection systems (IDS) and intrusion prevention systems (IPS)	p. 319
	• the role of ethical hacking	p. 324

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OUTCOME	KEY KNOWLEDGE	LOCATION
Interactions and impacts	• risks and benefits of using networks in a global environment	p. 324
	• key legislation that affects how organisations control the storage and communication of data and information: the *Health Records Act 2001*, the *Privacy Act 1988* and the *Privacy and Data Protection Act 2014*	p. 326
	• ethical issues arising from data and information security practices	p. 329
Key skills	• identify and describe the applications and capabilities of different networks	p. 284
	• examine the impact of common network vulnerabilities	p. 309
	• design a network solution with wireless capability	p. 297
	• identify and evaluate threats to the security of data and information	p. 309
	• propose and justify strategies to protect the security of data and information within a network	p. 313
	• identify and discuss possible legal and ethical issues arising from ineffective data and information security practices	p. 324

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Problem-solving methodology

When an information problem exists, a structured problem-solving methodology is followed to ensure that the most appropriate solution is found and implemented. For the purpose of this course, the problem-solving methodology has four key stages: analysis, design, development and evaluation. Each of these stages can be further broken down into a common set of activities. Each unit may require you to examine a different set of problem-solving stages. It is critical for you to understand the problem-solving methodology because it underpins the entire VCE Applied Computing course.

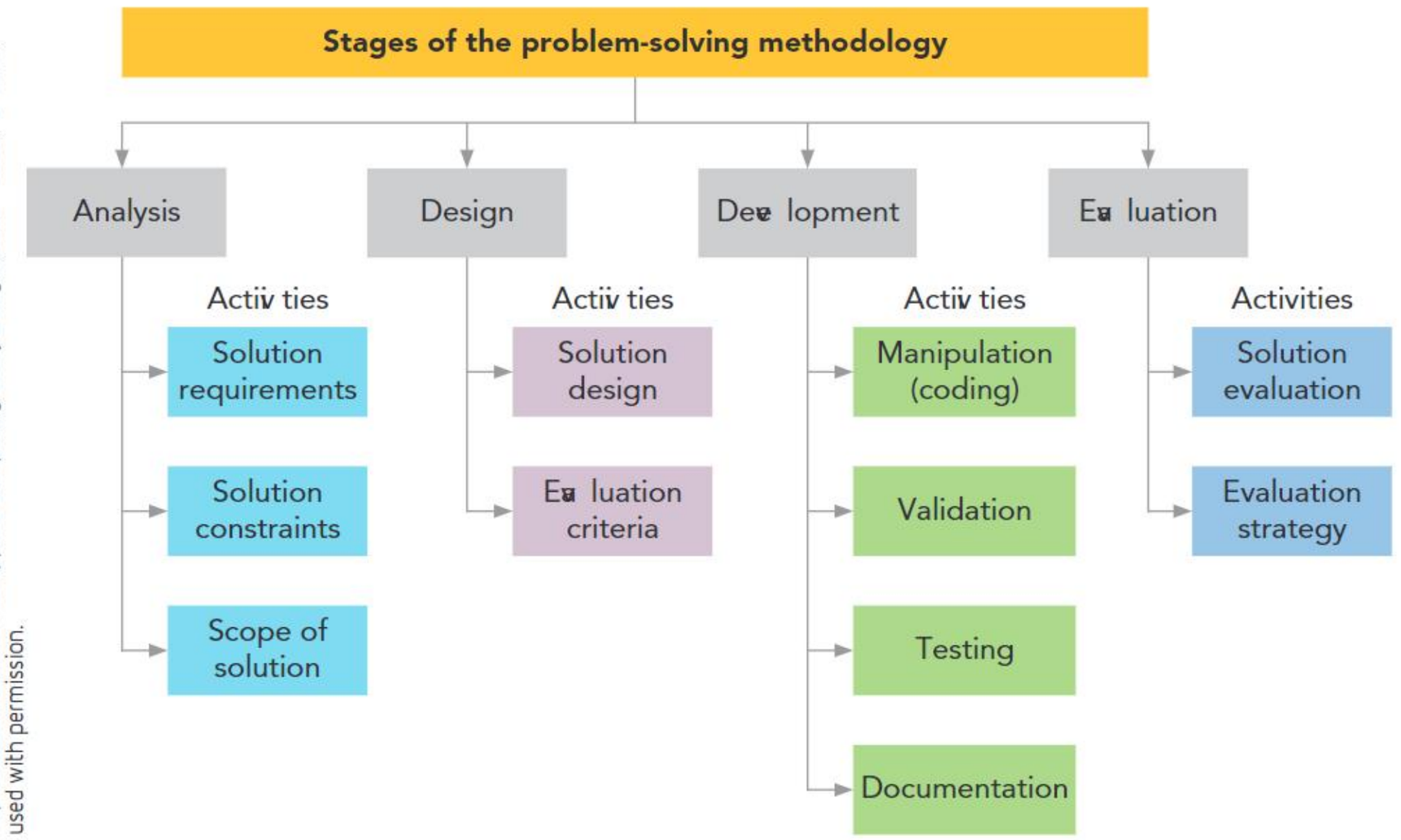

FIGURE 1 The four stages of the problem-solving methodology and their key activities

Analyse the problem

The purpose of analysis is to establish the root cause of the problem, the specific information needs of the organisation involved, limitations on the problem and exactly what a possible solution would be expected to do (the scope). The three key activities are:

1. identifying solution requirements – attributes and functionality that the solution needs to include, information it must produce and data needed to produce this information
2. establishing solution constraints – the limitations on solution development that need to be considered. Constraints are classified as economic, technical, social, legal and related to usability
3. defining the scope of the solution – what the solution will and will not be able to do.

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Design the solution

During the design stage, several alternative design ideas based on both appearance and function are planned and the most appropriate of these is chosen. Criteria are also created to select the most appropriate ideas and to evaluate the solution's success once it has been implemented. The two key design activities are:

1. creating the solution design – it must clearly show a developer what the solution should look like, the specific data required and how its data elements should be structured, validated and manipulated. Tools typically used to represent data elements could include data dictionaries, data structure diagrams, input–process–output (IPO) charts, flowcharts, pseudocode and object descriptions. The following tools are also used to show the relationship between various components of the solution: storyboards, site maps, data flow diagrams, structure charts, hierarchy charts and context diagrams. Furthermore, the appearance of the solution, including elements such as a user interface, reports, graphic representations or data visualisations, needs to be planned so that overall layout, fonts and their colours, for example, can be represented. Layout diagrams and annotated diagrams (or mock-ups) usually fulfil this requirement. A combination of tools from each of these categories will be selected to represent the overall solution design. Regardless of the visual or functional aspects of a solution design, at this stage a test for the design to ultimately ensure the solution is functioning correctly must also be created
2. specifying evaluation criteria – during the evaluation stage, the solution is assessed to establish how well it has met its intended objectives. The criteria for evaluation must be created during the design stage so that all personnel involved in the task are aware of the level of performance that ultimately will determine the success or otherwise of the solution. The criteria are based on the solution requirements identified in the analysis stage and are measured in terms of efficiency and effectiveness.

Develop the solution

The solution is created by the developers during this stage from the designs supplied to them. The 'coding' takes place, but also checking of input data (validation), testing that the solution works, and the creation of user documentation. The four activities involved with development are:

1. manipulating or coding the solution – the designs are used to build the electronic solution. The coding will occur here and internal documentation will be included where necessary
2. checking the accuracy of input data by way of validation – manual and electronic methods are used; for example, proofreading is a manual validation technique. Electronic validation involves using the solution itself to ensure that data is reasonable by checking for existence, data type and that it fits within the required range. Electronic validation, along with any other formulas, always needs to be tested to ensure that it works properly

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3 ensuring that a solution works through testing – each formula and function, not to mention validation and even the layout of elements on the screen, needs to be tested. Standard testing procedures involve stating what tests will be conducted, identifying test data, stating the expected result, running the tests, stating the actual result and correcting any errors

4 documentation allowing users to interact with (or use) the solution – while it can be printed, in many cases it is now designed to be viewed on screen. User documentation normally outlines procedures for operating the solution, as well as generating output (such as reports) and doing basic troubleshooting.

Evaluate the solution

At some time after a solution has been in use by the end user or client, it needs to be assessed or evaluated to ensure that it has been successful and does actually meet the user's requirements. The two activities involved in evaluating a solution are:

1 evaluating the solution – providing feedback to the user about how well the solution meets their requirements, needs or opportunities in terms of efficiency and effectiveness. This is based on the findings of the data gathered at the beginning of the evaluation stage when compared with the evaluation criteria created during the design stage

2 working out an evaluation strategy – creating a timeline for when various elements of the evaluation will occur and how and what data will be collected (because it must relate to the criteria created in the design stage).

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Key concepts

Within each VCE Applied Computing subject are four key concepts whose purpose is to organise course content into themes. These themes are intended to make it easier to teach and make connections between related concepts and to think about information problems. Key knowledge for each Area of Study is categorised into these key concepts, but not all concepts are covered by each Area of Study. The four key concepts are:

1. digital systems
2. data and information
3. approaches to problem solving
4. interactions and impact.

Digital systems focus on how hardware and software operate in a technical sense. This also includes networks, applications, the internet and communication protocols. Information systems have digital systems as one of their parts. The other components of an information system are people, data and processes.

Data and information focuses on the acquisition, structure, representation and interpretation of data and information in order to elicit meaning or make deductions. This process needs to be completed in order to create solutions.

Approaches to problem solving focuses on thinking about problems, needs or opportunities and ways of creating solutions. Computational, design and systems thinking are the three key problem-solving approaches.

Interactions and impact focuses on relationships that exist between different information systems and how these relationships affect the achievement of organisational goals and objectives. Three types of relationships are considered:

1. how people interact with other people when collaborating or communicating with digital systems
2. how people interact with digital systems
3. how information systems interact with other information systems.

This theme also looks at the impact of these relationships on data and information needs, privacy and personal safety.

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Unit 1

INTRODUCTION

VCE Unit 1 of Applied Computing looks at how software tools such as databases and spreadsheets can be used to create visualisations of data. Students also study programming languages.

Throughout the unit, students will apply the stages of the problem-solving methodology. They will plan and monitor the progress of the tasks using project-management concepts. Different types of data will be acquired and manipulated in database and spreadsheet software.

There are two outcomes to be completed in Unit 1.

Area of Study 1: Data analysis

OUTCOME 1 Your teacher will provide you with solution requirements and designs for which you need to gather and organise appropriate data, analyse it and present the findings as data visualisations. As part of the solution development you will need to validate your data and apply appropriate formats and conventions to the data visualisations.

Area of Study 2: Programming

OUTCOME 2 You will be provided with a set of program requirements by your teacher. You are to use these specifications to design, develop and evaluate a solution created in a programming language. You will monitor the progress of your programming project, although you do not need to use project-management software.

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CHAPTER

1 Data analysis

KEY KNOWLEDGE

On completion of this chapter, you will be able to demonstrate knowledge of:

Data and information

- types and purposes of qualitative and quantitative data
- characteristics of data and information
- sources, methods and techniques for acquiring and referencing primary and secondary data and information
- interpretation of information for communication and decision making
- factors affecting the quality of data and information such as accuracy, bias, integrity, relevance and reliability
- characteristics of data types and data structures relevant to selected software tools
- procedures for the legal and ethical collection and use of data and information, such as using consent forms
- techniques for protecting data and information from misuse, such as de-identifying personal data and the use of physical and software security controls

Interactions and impacts

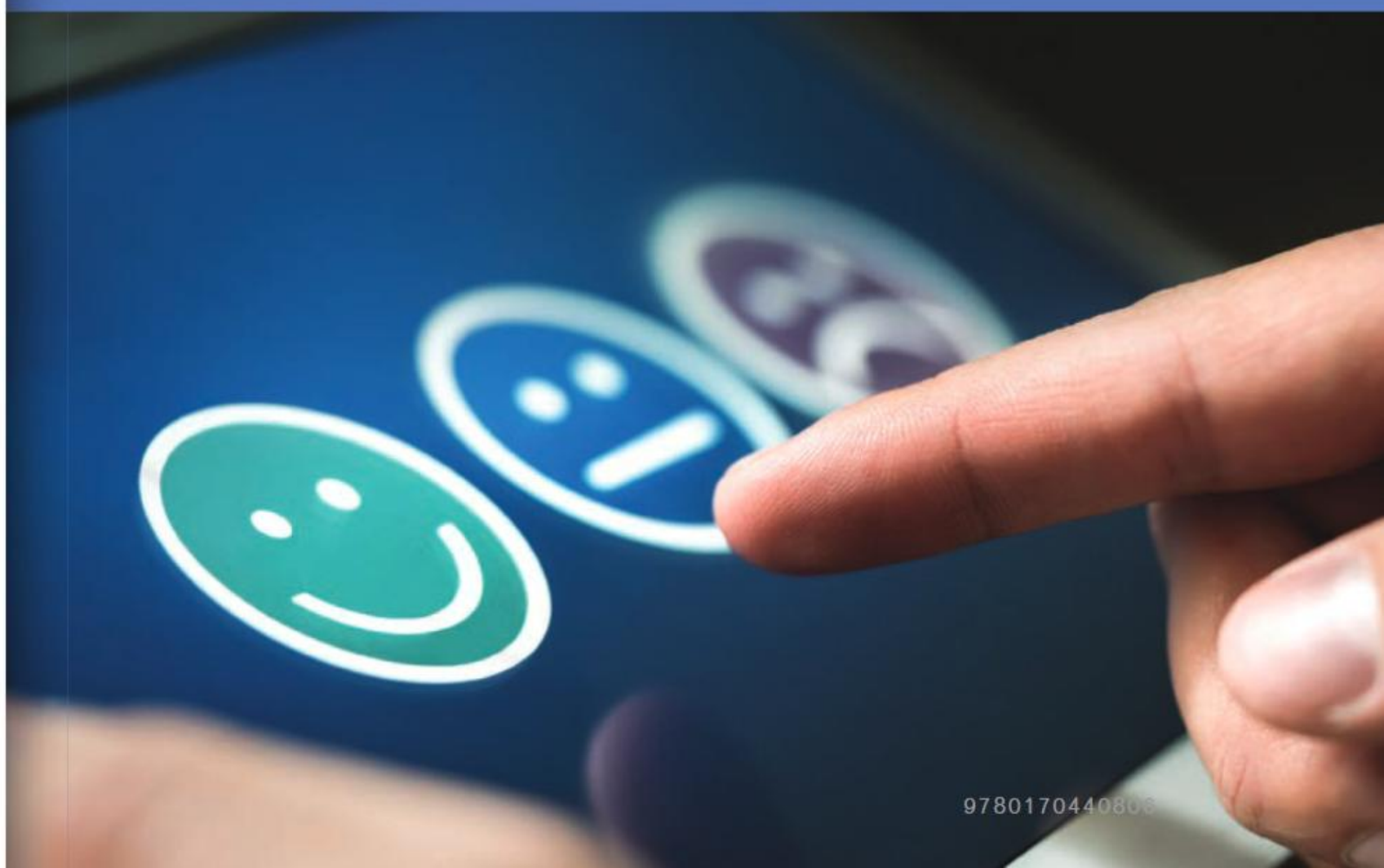
- Australian Privacy Principles relating to the acquisition, management and communication of data and information such as non-identification of individuals (Principle 2), information only being held for its primary purpose (Principle 6) and the security measures used to protect personal information (Principle 11)
- ethical issues arising from the acquisition, storage and use of data and information

FOR THE STUDENT

In this chapter, you will respond to a teacher-provided analysis of requirements and designs to identify and collect data in order to present your findings as data visualisations.

FOR THE TEACHER

This chapter is based on Unit 1, Area of Study 1, and, together with Chapter 2, provides the key knowledge required to complete Unit 1, Outcome 1. At the end of Chapters 1 and 2, students should be able to interpret teacher-provided solutions requirements and designs, collect and manipulate data, analyse patterns and relationships, and develop data visualisations to present findings.



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Understanding research

Some people consume research, and others produce research. Consumers of research spend a lot of time reading other people's research rather than conducting their own. On the other hand, producers of research investigate or explore an area that has relevance to them, interpret their **data** and then communicate their findings.

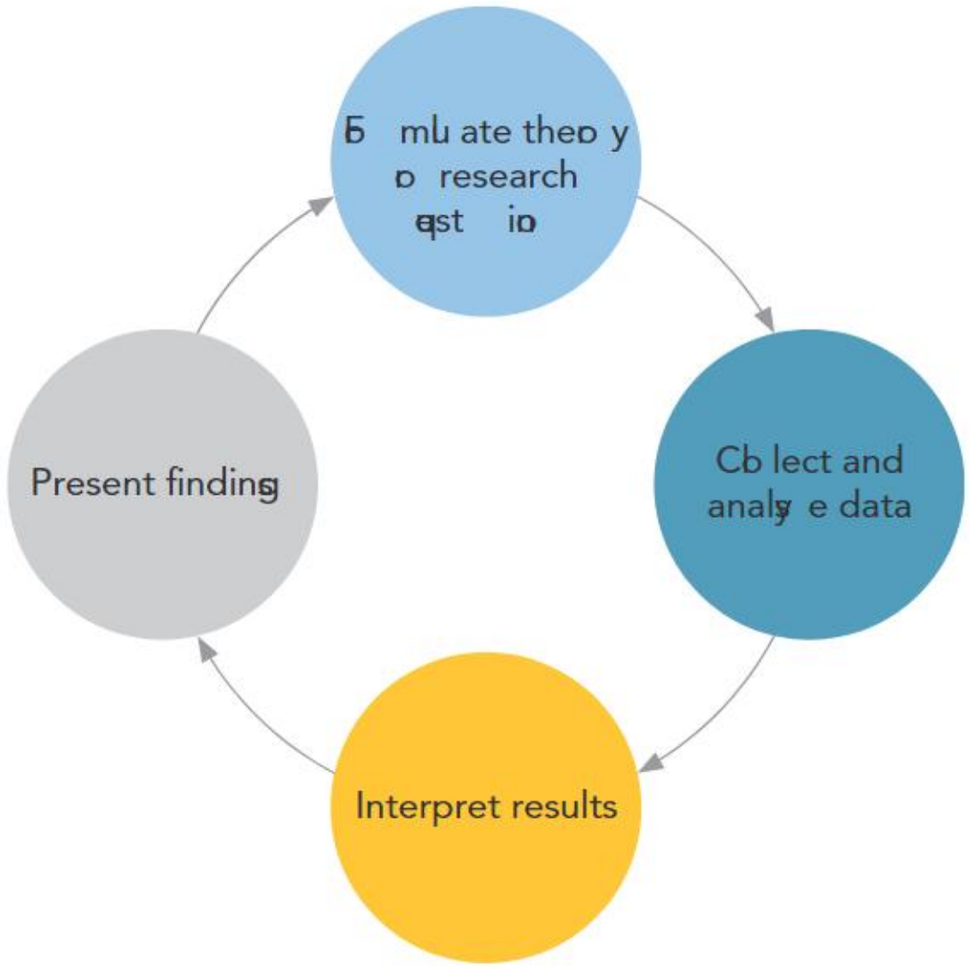

FIGURE 1.1 Producers of research often start with a theory or a research question.

Theories are usually general statements that describe something, provide an explanation of why something happens, and can be applied to predict what will happen in the future. Theories are, in principle, falsifiable or disprovable; that is, they contain information about the sorts of events that, if they were to happen, would show the theory to be false.

Some research questions are tied closely with theories. **Research questions** assist researchers to narrow the focus of the topic of the investigation. For example, 'Is therapeutic exercise of benefit in repairing cognition impairment in octogenarians?'

Hypotheses, on the other hand, are based on probabilities about what will happen according to the applied theory. Theories are tested by using data-collection tools such as surveys and/or interviews, and then the results of the study will either confirm or disprove the hypothesis.

Types of research

Investigating or researching topics of interest may be undertaken using quantitative or qualitative research methods.

Quantitative data is measurable and specific, and is therefore relatively easy to chart or graph. At a simplistic level, quantitative data gathering is based on verifying a research question through the use of statistics and data that is largely numerical, while qualitative data provides a more in-depth understanding.

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The following is an example of quantitative data:

> 56.0 per cent said a lack of role models was a significant or moderate obstacle to their career advancement.

Professionals Australia (2018). *All Talk: Gap between policy and practice a key obstacle to gender equity in STEM – 2018 Women in STEM Professions Survey Report.* August 2018, page 32.

When data has been gathered using surveys, focus groups, observation or other methods, quantitative data can be analysed by using software such as Excel, the Statistical Package for the Social Sciences (SPSS) and Minitab. This takes time and often involves hours of data entry, depending on the complexity of the data-gathering instrument. For data gathering, online surveys such as SurveyMonkey, Qualtrics, Google Forms and Microsoft Forms allow users to create surveys and manage the collection and analysis of quantitative data.

SPSS and MiniTab are statistical software packages used to analyse quantitative data.

Qualitative data is about qualities or attributes, and is much harder to measure than quantitative data. You can gather qualitative data using instruments such as interviews, focus groups, video footage and observation. Generally, qualitative data needs to be recorded accurately and transcribed at a later stage. Online survey software permits qualitative data to be entered through text boxes.

The analysis of qualitative data is quite different from that of quantitative data. With quantitative data, the researcher looks for themes or patterns through the use of numbers, while with qualitative data, the researcher establishes rich descriptions and finds themes through reading the text and classifying these themes. The following example of qualitative data gathering is more descriptive:

NVivo is an example of a software package designed to help with the analysis of qualitative data. It lets a researcher sort and classify qualitative (non-numerical) information, identify relationships within it and examine whether it supports particular hypotheses.

> Survey respondents noted that a lack of role models and the lack of women both in the workplace and in senior roles were issues that impacted them. Respondents also noted that women in senior roles were not necessarily always positive role models and that in male-dominated workplaces and professions, career support and advancement for women could often depend on positive male role models.

Professionals Australia (2018). *All Talk: Gap between policy and practice a key obstacle to gender equity in STEM – 2018 Women in STEM Professions Survey Report.* August 2018, page 32.

Advantages and disadvantages of quantitative and qualitative data

Participants are more willing to be part of a quantitative study as it is less demanding of them. Often, quantitative studies use surveys, which can capture a large sample. Having a large sample size provides statistical validity, and helps to accurately reflect the characteristics, attitudes or views of the population. Data is interpreted, relationships are identified and findings are then communicated. Conversely, because surveys do not have a provision for probing the participants further, the answers provided do not have as much depth and are at times superficial. If too much information were provided, researchers would be overwhelmed by the amount of data collected and would not be in a position to analyse it. This can also be due to time and budgetary constraints.

Qualitative research provides for rich, in-depth studies of participants. Researchers can ask further questions, especially if something of interest arises. Generally, qualitative studies are small, and provide a narrative description of a sample group. Data-gathering tools can include interviews and focus groups. However, because the sample size is small and the sample is not very random, conclusions may not generalise readily to a larger sample size. Findings may be peculiar to a particular sample.

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Data and information

The terms 'data' and 'information' are often used interchangeably. Data refers to the raw, unorganised facts, figures and symbols. Data can also mean ideas or concepts before they have been refined. In addition to text and numbers, data also includes sounds and images (still and moving).

Information is produced when data is manipulated into a meaningful and useful form. This can be achieved by organising the data and presenting it in a way that suits the needs of the intended audience. The information produced can be used to inform, entertain or persuade an audience. When information makes it possible to identify individuals, protecting their privacy becomes a consideration.

Technically speaking, a datum is a single item of data; however, the term 'data' is commonly used and accepted as both the singular and plural forms of the word.

Primary and secondary data and information

There are many sources of data and information, and many methods and techniques used to collect it. These include:

- what people say in interviews, focus groups, questionnaires/surveys, personal histories, biographies;
- images, audio recordings and other audio-visual materials;
- records generated for administrative purposes (e.g. billing, service provision) or as required by legislation (e.g. disease notification);
- digital information generated directly by the population through their use of mobile devices and the internet;
- physical specimens or artefacts;
- information generated by analysis of existing personal information (from clinical, organizational, social, observational or other sources);
- observations;
- results from experimental testing and investigations; and
- information derived from human biospecimens such as blood, bone, muscle and urine.

National Health and Medical Research Council.
National Statement on Ethical Conduct in Human Research 2007 (updated 2018). Page 33.

Sources

Primary sources of data provide a firsthand account of a person, object, event or phenomena. Many of the methods and techniques outlined in the National Statement on Ethical Conduct in Human Research are sources of primary data. Questioning them or surveying their opinions can provide different insights and more in-depth data than using information from **secondary sources**. The data will often be more up-to-date and can provide more unusual and important insights into issues, especially at the immediate local level, than secondary sources, which often present overall conclusions and general summaries.

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Techniques and methods

Collecting data is usually done through methods such as surveys and interviews. While the results of surveys are easy to present graphically, interview results often can only be presented as written summaries and conclusions. However, both require analytical discussions to interpret their meaning.

Surveys contain a range of questions that relate directly to the research question being investigated. Participants may answer these questions by selecting a response from a list of alternatives, such as A/B/C/D, selecting multiple options from a given list, using a Likert scale (either 1 to 5, very low to very high, strongly agree to strongly disagree), or in short or extended text-based responses.

Interviews are usually conducted face to face, sometimes in groups, and, depending on the number of interviews being conducted, it can take a substantial amount of time to conduct and analyse the responses. A major feature of an interview is the opportunity for in-depth follow-up and clarification questions. These are not possible with surveys, which are often answered in private. Interviews are very useful for eliciting people's feelings, attitudes and opinions, which are too complex to easily record in a survey.

A group interview is also known as a focus group.

Data collection methods

Before we can produce information, we first must start with data. Methods such as surveys, interviews or observation provide a means of capturing data. Other ways to collect data electronically include using sensors, such as traffic cameras and satellites, and online sources, such as websites or data logs. The data collected can be used for a variety of purposes, including describing, predicting and improving processes within an organisation or for research.

Surveys

Surveys are common methods used to collect data. They can provide data about what the respondents think is true, or their preferences for consumer goods and political parties. A survey can be a quick way of gathering large amounts of data. Surveys need to be carefully designed, otherwise the participants' responses may not provide suitable data to analyse, rendering them useless. Questions used in a survey must be carefully worded so that the response will provide meaningful and useful data without the need for further clarification.

Focus groups

A **focus group** is the meeting of a small group of individuals who are guided through a discussion by a researcher, similar to a group interview. The group is carefully selected to fit a particular demographic and so the researcher can obtain the necessary data through a guided discussion that probes the participants' attitudes about the topic. Focus groups often comprise between five and 12 people and the discussion is loosely structured to encourage ideas to flow.

Interviews

Interviews are used to elicit people's opinions and beliefs. They can be used to gather data for research projects. Interviews are usually conducted with one or more participants in a

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quiet and relaxed atmosphere. They should be recorded, with the interviewee's permission, with easily used and unobtrusive audio or video equipment. Writing down the responses during the interview is not helpful to the interviewer or the interviewee. These records are research data in themselves, but may also be transcribed later. Collating and analysing information can be difficult and time-consuming and may require the use of someone with expertise. There are many interview styles that can be used:

- structured interviews, which follow a set list of questions
- semi-structured interviews, which follow a list of issues to be explored
- unstructured interviews, which involve spontaneous generation of questions and where the interview is driven by the interviewee rather than the interviewer.

Open-ended and closed questions

Questions used on a survey and during an interview can be open-ended or closed. **Closed questions** limit the responses available to the respondent (Figure 1.2, page 8). They include 'Yes/No' boxes, multiple-choice questions, and scales on which attitudes and beliefs are measured using responses such as 'strongly agree', 'agree', 'disagree' or 'strongly disagree'.

Closed (or closed-ended) questions are generally considered to be quantitative in nature. They are called 'closed' because the range of answers the participant can choose is limited. They are considered to be quantitative because the response options can be converted to numbers. For example:

How often do you wash your car?

5 I always wash my car.
4 I sometimes wash my car.
3 I occasionally wash my car.
2 I wash my car once in a while.
1 I never wash my car.

Each of these options can have a value placed next to it. However, we do not talk in numbers and we shouldn't create surveys that only have numbers. Surveys should be thought of as a conversation between the person asking the questions and the person answering them.

Open-ended questions do not limit the answers that the respondent can give (Figure 1.3, page 8). They should be worded so that the responses received are capable of correct interpretation. For instance, if you asked the question, 'How do you feel about the widespread use of computer games?', the responses would probably be too broad to be usefully categorised and analysed. The wording must therefore limit the scope of the possible responses to specific areas of interest: 'How has the playing of computer games affected your child's school results?' Open-ended questions also allow for follow-up questions, which are called probing questions, such as 'Why?' or 'Please give an example'. Such questions tend to elicit more detail.

Open-ended questions are 'open-ended' because participants are free to answer in any manner they choose. Unlike closed questions, there are no response options specified. They are qualitative because responses are considered and measured by feel rather than by numbers.

THINK ABOUT APPLIED COMPUTING 1.1

What types of charts would you use to display the aggregated responses to closed questions?

Closed questions are easier to develop, quicker to administer and answer, easier to collate and analyse, and can provide a large and balanced sample; however, they may not be useful for complex issues. In this case, open-ended questions may be needed as they elicit greater detail in the responses, can bring forth unusual ideas and can show links between various aspects of the issues.

Closed questions
1 How long have you shopped at this store?
2 How many times per week do you go shopping?
3 How much do you spend per week?
4 Which of the following sources of information most influences your purchasing habits?
• Advertising pamphlets delivered to the home
• Newspaper advertisements
• Television promotions
• Recommendations from friends
5 Do you use a computer? • Yes • No
6 What time of day do you normally go shopping?

FIGURE 1.2 Closed questions should be designed to elicit short, straightforward answers.

Open-ended questions
1 What is your opinion of the games available from this store?
2 How influential do you think the advertising campaign has been?
3 What are some of the errors in data entry that you have observed?
4 Describe the most frustrating experience you have had when using the computer system.
5 What are some of the problems you experience in receiving information on time?
6 What changes would you recommend to improve the billing system?

FIGURE 1.3 Open-ended questions try not to limit the answers the respondent can give.

Observation

Observation is a way of understanding the world around us as well as developing an understanding of existing processes. Using our senses (sight, smell, hearing and touch) we are able to pick up detailed information about our environment. However, as a method of data collection, observation is more than just looking or listening, as we can be selective about what we perceive to be most useful to us. Researchers engaged in observation attempt to learn what life is like for someone in a particular setting, while they themselves remain outsiders. While observing, they make careful notes of what they see, and record all accounts including conversations and interactions. Observation generally takes place in community settings, such as classrooms, or in locations believed to have some relevance to the research questions. Observation is unlike other forms of data-collection tools, as the researcher approaches participants in their own environment rather than having the participants come to the researcher.

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Referencing primary sources

Once primary data has been gathered, details need to be carefully recorded to enable appropriate **referencing**.

Interviews

For an interview, the following details need to be documented so that an interested person can go back to the source for checking, clarification and further information:

- name of interviewee
- date of interview
- place of interview
- qualification to be an interviewee – that is, whether the interviewee is a **stakeholder** in the issue and/or an expert about it
- organisation to which the interviewee belongs (if relevant)
- contact information for interviewee – phone number, address, email address, online chat handle
- how the interview was conducted; for example, in person, by phone, email or online chat
- name and contact details of interviewer.

Surveys

If you want to cite an individual response to a survey, you need to record these details:

- name of respondent
- when the survey was completed
- title of survey
- organisation to which the survey belongs (if relevant)
- how the survey was conducted – paper/online.

Observation

For observation, the following details need to be recorded:

- the name of the person or group of people observed
- when the observation was conducted (date/time)
- where the observation was conducted.

Examples of referencing

Citations in a document help readers to find the source of the information and also assist students to avoid **plagiarism**. There are many ways to cite sources, such as providing footnotes or in-text citations, or listing sources at the end of the document in a bibliography or reference list.

Footnotes

Footnotes are listed at the bottom of the page on which a citation is made. Some academic disciplines prefer to use footnotes (notes at the foot of the page) to reference their writing. Although this method differs in style from the 'author, date' system, its purpose – to

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